BioFacts

Fueling a Stronger Economy

Thermochemical Conversion of Biomass

A primary mission of the U.S. Department of Energy (DOE) is to stimulate the development, acceptance, and use of transportation fuels made from plants and wastes called biomass. Through the National Renewable Energy Laboratory (NREL), DOE is developing an array of biomass conversion technologies that can be easily integrated into existing fuel production and distribution systems. The variety of technology options being developed should enable individual fuel producers to select and implement the most cost-effective biomass conversion process suited to their individual needs.

Current DOE biofuels research focuses on the separate and tandem use of biochemical and thermochemical conversion processes. This overview specifically addresses NREL's thermochemical conversion technologies, which are largely based on existing refining processes.

Thermochemical conversion of biomass can produce a variety of versatile liquid fuel products, including ethanol, methanol, diesel, ethers for reformulated gasoline, and even a form of refinable crude. Some of the thermochemical technologies for producing these energy products are ready for commercialization; however, much of the effort for producing biomass-derived fuels is still at the research stage. NREL's thermochemical conversion project is pursuing technical feasibility along two separate avenues of research: gasification/fuel synthesis and fast pyrolysis/catalytic cracking.

Gasification/Fuel Synthesis

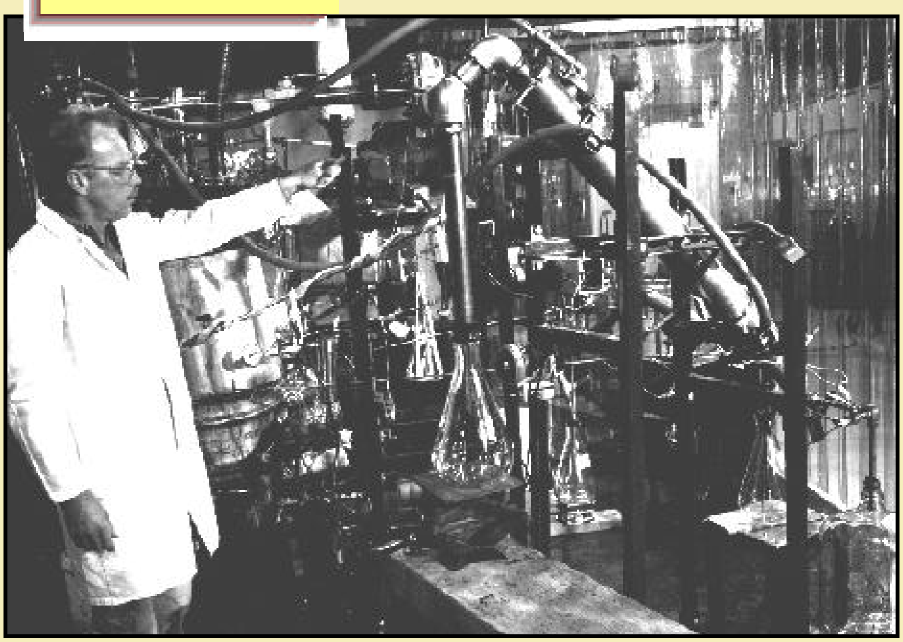
Products such as methanol, isobutylene, higher alcohols, hydrogen, gasoline, and diesel can be produced from biomass using the processes of gasification and fuel synthesis in tandem.

Bagasse, the residue from sugarcane, is an excellent form of biomass that can be treated thermochemically to produce an number of biofuels.

Gasification uses heat—often in conjunction with pressure—to convert biomass directly to a synthesis gas (syngas), composed primarily of carbon monoxide and hydrogen. The syngas is then conditioned to remove impurities such as particulate matter, light hydrocarbons (e.g., methane), and tar. In addition, the hydrogen:carbon monoxide ratio of the syngas is adjusted, or reformed, to the optimum ratio for the particular fuel being produced. For example, the optimum ratio for methanol is 2 parts hydrogen to 1 part carbon monoxide.

The processes required for the production of syngas from biomass have been demonstrated at the laboratory and pilot scales. Methanol, gasoline, and diesel can already be produced from syngas via traditional, commercially available technologies. Methanol, higher alcohols, and diesel have also been synthesized using improved reactor technologies still under development. The overall goal of biomass gasification/fuel synthesis research is to integrate the complete biomass-to-fuels process at the laboratory and pilot scales, followed by subsequent commercial demonstration and use.

Researchers are evaluating a wide variety of process operating conditions using the most promising catalysts.



In October 1993, construction began on a 100 ton/day (91 megagram/day) biomass gasifier facility in Hawaii. The project is a collaborative effort sponsored by DOE through NREL, the State of Hawaii, and the Pacific International Center for High Technology Research (PICHTR). The plant will initially gasify sugarcane residue, called bagasse; however, it is designed to gasify a wide variety of biomass, including chips from whole trees, clean wood wastes, and dry solids gleaned from municipal solid waste. Phase 1 of this project—design, construction, and initial operation of the plant at a 50 ton/day (45 megagram/day) capacity—concludes in 1995. During Phase 2 (scheduled for completion in 1997), the plant will be expanded to include a gas turbine for generating electricity from the syngas. In Phase 3 (slated to finish in 1999), a fuel synthesis system that converts syngas into methanol will be incorporated.

The goal of DOE's gasification/fuel synthesis program is to produce biomass-derived methanol for sale at $0.50/gallon ($0.13/liter). Compare this to the market price of methanol (produced from natural gas) today, which ranges from $1.30 to 1.80/gallon ($0.34 to $0.48/liter).

Fast Pyrolysis/ Catalytic Cracking

Biocrude, a product similar to petroleum crude, can be produced from biomass using an NREL-developed fast pyrolysis process. This new process uses the rapid and controlled application of heat to convert biomass into oxygen-containing crude oil vapors. Fast pyrolysis has been demonstrated using an innovative vortex reactor that can convert 50 pounds (23 kg) of wood per hour into hydrocarbon-rich crude oil vapors.

Biocrude is formed when the biomass-derived oil vapors are condensed. The biocrude can be processed into a replacement for #6 fuel oil, which is often used as a liquid boiler fuel. Future research will focus on altering the chemical composition of biocrude so that it can be combined and processed with petroleum crude in modified petroleum refineries. This upgraded biocrude would increase the total available supply of domestic crude and could become a component of all products produced at the refinery.

NREL is currently involved in a cost-sharing contract with Interchem Environmental, Inc. The firm is constructing a 35 ton/day (32 megagram/day) version of NREL's vortex reactor, which is being built according to NREL specifications. When completed, the firm will convert waste wood into a fuel oil replacement. Ongoing research indicates that the firm's biocrude may also be a suitable fuel for use in turbine engines. In addition, Interchem Environmental, Inc., will sell the by-product char to a charcoal briquette manufacturer.

When fast pyrolysis is used in tandem with a process called catalytic cracking, an olefin-rich stream suitable for producing ether can be formed. Catalytic cracking (an extension of fluidized catalytic cracking technology used by the petroleum industry) converts biocrude into olefins, carbon monoxide, carbon dioxide, and water. The olefins can be used to make isobutylene. By reacting ethanol or methanol with isobutylene, refiners could produce biomass-derived ethers, ethyl tertiary butyl ether (ETBE) and methyl tertiary butyl ether (MTBE), respectively, for use in reformulated gasoline. Researchers are using a 50 pound/hour (23 kilogram/hour) riser cracker reactor to identify catalysts that preferentially produce olefins, instead of other hydrocarbons or coke, from biocrude. Industry has expressed considerable interest in NREL's riser cracker technology.

Many different forms of biomass can be converted into biocrude using the pyrolysis process. Current pilot systems use wood and grass. Some biomass contains higher levels of hydrocarbons and is more efficient and cost effective for ether production. The most likely near-term biomass resource for commercial ether production is refuse-derived fuel (RDF)—the organic portion of municipal solid waste. The plastics contained in the RDF add essential hydrocarbons that increase the yield of olefins. RDF currently contains about 6%–8% by weight nonrecyclable plastics, and researchers predict that the plastics content of RDF may grow to as much as 20% by 2000. This implies that landfills could become profitable "oil fields" in the future.

This gasification plant in Hawaii will initially process bagasse from the neighboring sugarcane refineries, but is designed to receive a wide variety of biomass.

National laboratories, universities, and industry are collaborating on large-scale experiments on the most promising grasses and fast-growing trees for use as energy crops.

Biomass Energy Crop Research

Although municipal solid waste, wastewood, and agricultural residues provide the most likely near-term biomass for biofuels production, the growing demand for biofuels will necessitate a large, reliable source of raw biomass materials. Therefore, energy crops are being developed to fulfill the long-term demand for biofuels. Following 8 years of work to identify and screen potential energy crops, researchers at Oak Ridge National Laboratory are collaborating with universities and industry to conduct large-scale experiments on the most promising grasses and fast-growing trees. These researchers are assessing the potential impact of energy-crop farming on ecosystems, farmland, soil erosion, water quality, and wildlife. Energy-crop researchers are also assessing the crops' suitability for thermochemical processing and adaptability to transport and storage. In particular, energy crops rich in hydrocarbons are desirable for thermochemical processes.

Research and Development Funding

It's no secret that basic research and development (R&D) is an expensive, long-term endeavor. With the current strong focus on end-use markets and some biofuels technologies nearing commercial application, industrial support for biofuels development is increasing. Significant investments are being made in engineering-scale pilot plants, and the potential economic and regional impacts of biofuels production have attracted interest from several state governments.

The involvement of the private sector in many aspects of DOE's biofuels R&D program helps ensure that program goals and priorities are relevant to the needs of industry and that the resulting technologies can be readily applied when market conditions allow. Federal investment in biofuels R&D is increasingly being matched by industry partners through joint ventures, consortia, and cooperative research and development agreements (CRADAs).

With continued government and industry support, DOE can help industry develop the transportation fuels that will meet the demands of tomorrow's consumer, safeguard the environment, increase farm and nonfarm employment, and meet the demands of the transportation fuel producer's bottom line.

Call Us For More Information

Dan Tyndall
Thermochemical Conversion Project
303/275-4483

Noni Strawn
Biofuels Information Center
303/275-4347

National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393

Produced for the
U.S. Department of Energy
by the
National Renewable Energy Laboratory

NREL/SP-420-6379
DE94006866
December 1994

Printed with a renewable source ink on paper containing at least 50% wastepaper, including 10% postconsumer waste